GEORGE'S ROCKETRY PAGES HOME Back to Projects and R&D

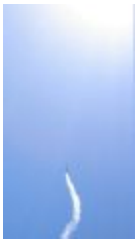
Sun Guidance

1988 R&D Project

Sunguidance is an R&D project that our Zunofark Team entered and won first place at NARAM-30 in 1988 (in Huntsville). Sunguidance is based on using sun sensing to guide a model to fly towards the sun (or fly near vertically on overcast days). The 1988 test models used aerodynamic controls, nose fins with a test model based on the Sidewinder missile design.

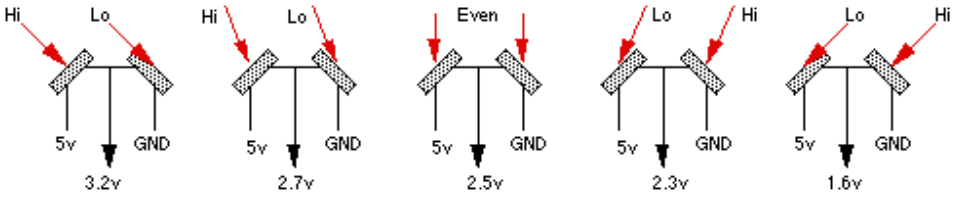
Copies of the 1988 Sunguidance report, laid out by Jim Cook, are available from **NARTS** (TR#-204). If you are interested in knowing the real details about how Sunguidance works, and perhaps want to build your own, please get this report from NARTS. What follows is only a brief description and wrap-up.

The guidance system as finalized is relatively simple (when it start,ed it was more complex). A pair of photo-resistors are wired in series, with a voltage tap between the first and second photoresistor. One photoresistor faces out one side, and the other faces the opposite side. They are shielded from direct sunlight, a typical blow-molded plastic nose cone is translucent enough to work fine.

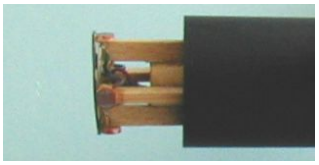


If the input voltage is for example 5 volts, and if both photoresistors receive equal light on each side, then the voltage will be 2.5 volts. If more light shines on one side than the other side, then the photoresistor with more light will have a lower resistance than the other one, causing the voltages to shift either above or below 2.5 volts.

Sun angles on photoresistors with resulting relative voltage changes (example values only)



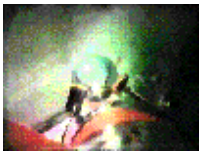
Nose Cone removed, showing photoresistors



Close-up view of sensor assembly

The voltage is fed into a very simple servo control circuit, to command one servo. The circuit is adjusted so that with 2.5 volts, the servo makes the flight surface move to neutral. When the voltage goes above 2.5 volts, then the servo moves the control surface one way, and if below 2.5 volts, it moves the other way.

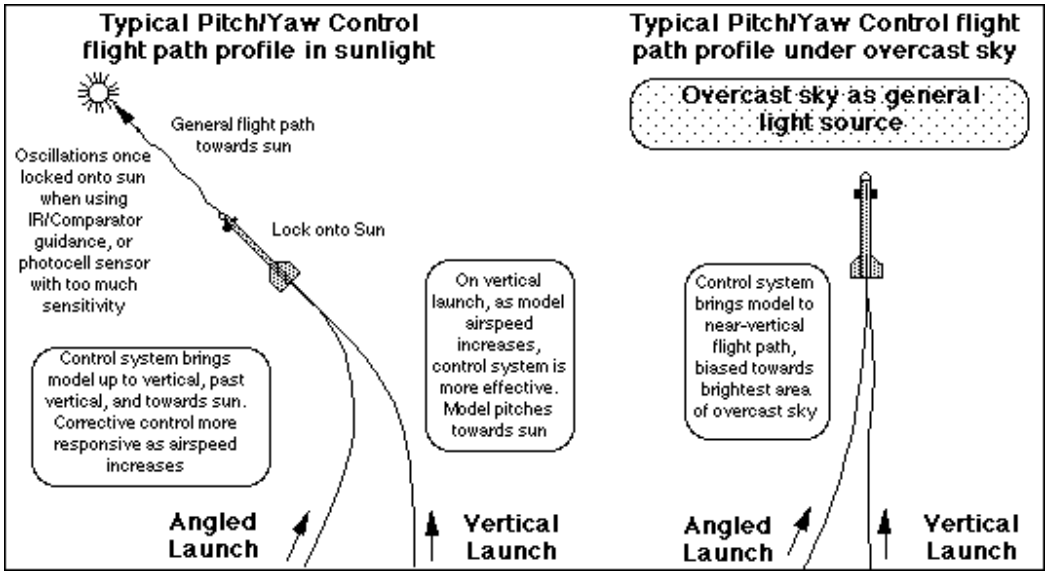
So, no very complex circuitry was needed for this. Just a two-servo control circuit, and two pairs of series-wired photo resistors to produce the control voltages for pitch and yaw.

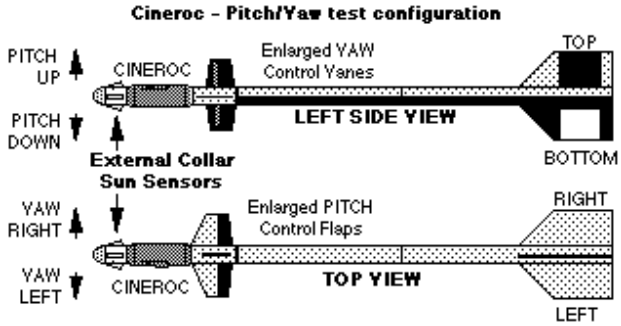


Five 1988 Sunguidance

Since the system uses photoresistors, it only works with normal visible light. It does not work off of infrared. If the sun is out, all it can track is the sun. It can NOT try to home in on anything, the only thing it can try to "hit" is the sun! If the sky is overcast, the overcast clouds make the guidance system steer the model near-vertically.

That in a nutshell is basically how the system works. If anyone is interested in knowing more, especially if you want ot make one of your own for models, then I urge you to purchase the 1988 R&D report from **NARTS** (TR#-204).


Typical Pitch/Yaw Control flight path profile in sunlight
Typical Pitch/Yaw Control flight path profile under overcast sky
Overcast sky as general light source
General flight path towards sun
Oscillations once locked onto sun when using IR/Comparator guidance, or photocell sensor with too much sensitivity
Lock onto Sun
Control system brings model up to vertical, past vertical, and towards sun. Corrective control more responsive as airspeed increases
On vertical launch, as model airspeed increases, control system is more effective. Model pitches towards sun
Control system brings model to near-vertical flight path, biased towards brightest area of overcast sky
Angled Launch
Vertical Launch
Angled Launch
Vertical Launch



1988 Sidewinder style Sunguidance test model, BT-60 tubing

The Sunguidance model has made many sport flights since 1988.

The model has only crashed two times, both due to mistakes in prepping. The first was during the 1988 project, when I accidentally put the second stage D12-5 engine in backwards, ejection charge end down. So, it did not stage, and fell to the ground. However, it did try to steer itself, and hit the garden at a shallow angle, which prevented major damage (a normal rocket would have hit the ground vertically). The Sunguidance system was still working even though some of the nose control surfaces had broken off. The other crash was by allowing the battery to get too low before launch. There were delays in flying, and by the time it took flights were made using a Cineroc, 2 for roll tests and 3 for pitch-yaw tests. Click here to download a Zipped 1.5 meg Quicktime movie (160 x 120 pixels). This is from the 5th flight which was three-staged using Chad-staged D12-0/D12-0/D12-5.

Thanks to: Matt Steele for the use of his Cineroc, the late "Mr Cineroc" Herb Desind for arranging for the film loading and processing, and Tom Beach for the QuickTime movie conversion.

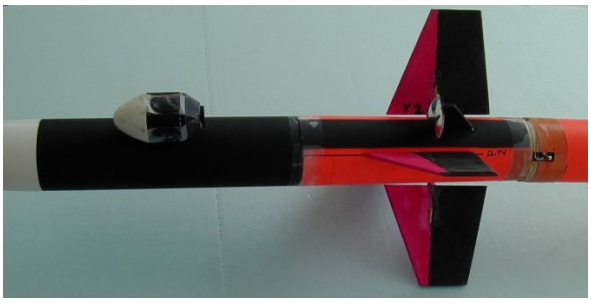
2005 Update - Sunguidance Flights resume! Gearcam Onboard video instead of a Cineroc. Go to the Video page.

A follow-up project in 1989, Gimbaled engines. The photo above shows the first gimbaled flight, steering for the sun (to the right). There is more information on this project near the bottom ofthis page.

off, the battery had gone dead, and the control surfaces were deflected in a way that made it half-loop into the ground.

I got a BoosterVision onboard video camera for Christmas in 2004. I added a small external mount for the camera, which was like a "flea" compared to when the model was flown with a Cineroc in 1988. Several good onboard video flights were made.

Right: 2005 update, with BoosterVision camera pod. Also, a chrome curved disc to act like a convex mirror to show the sun position, similar to the 1988 Cineroc flights which used a chrome button.

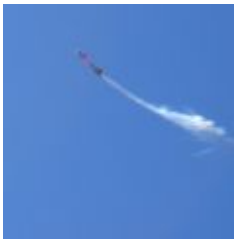


Flight sequence at SEARS launch, March 5th, 2005

Flight at SEARS launch, March , 2005

Climb on D12-0

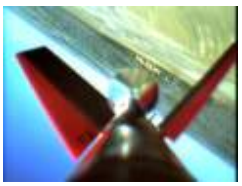
Sun is to the left



Staging of D12-5. Model has overshot the sun and is correcting.

Launch - note control surface angles

Model now locked-on to sun.



Apogee

Apogee, image rotated level

Chute deploy

George aiming receiver antenna

For more info on this flight, **click here** to go to a page which includes links to onboard and ground-based videos.

Eleven Minute Movie (edited April, 2008) - Movie showing both ground-shot video and onboard video, Including all Five of the **Sunguidance R&D Project Cineroc** Film flights in 1988 (showing ground-based video, then onboard, flight by flight).

Add Tom Beach, Chris Taylor N-48 video, etc.

Gimbaled Engine Guidance

1989 R&D Project

In 1989, our Zunofark Team did another Guidance R&D project which involved the use of gimbaled engines for model rocket guidance. Sunguidance was used as the guidance system. The first test flight was two-staged, a fixed D12-0 first stage to take off to a safe altitude, then a gimbaled D12-5. It worked, and as far as I know, was the first gimbaled-engine model rocket. Later flights were gimbaled at launch, first with an F15, then the rest with F10 powered flights.

Sunguidance did not prove to be too well suited to gimbaled flight, introducing major course corrections at liftoff. Often with problems of overcontrol. As well some flights rolled too quickly for the servos to keep up with, resulting in ballistic flights. Nonetheless, the 1989 project also won R&D that year, at NARAM-31.

There have been notable successes with Gimbaled engine Guidance since then, systems which had the engine STRAIGHT at liftoff (vertical launch angle, vertical engine). David Gianokos' team who developed a "true gyro" with a spinning Piezo DISC and optical tilt sensors, which worked great n a test model. David had developed it when he planned to fly his very large 1/48 scale Saturn-V. He chose not to risk it, and now his Saturn-V is at the NASM along with a Soviet N-1 rocket he built for the NASM to the same scale.

Another notable Gimbaled Engine project was by Scale expert John Pursley. He used on in a Mercury Redstone Model in 1998. He perfected it more since then. It makes use of a combination of model airplane type Gyros and horizon Sensors (modified). An onboard computer gave the gyros priority for the initial climb phase, then switched over at a certain point of the flight to the Horizon Sensors. This is because Horizon Sensors are not as reliable below 50 feet of altitude or so, and model plane type gyros drift pretty fast and cannot hold the course of a rocket flight over time. So, John's solution to use the strengths of both was quite brilliant.

First Gimbaled Guidance Flight Spring 1989

Major course change of gimblaed 2nd stage D12 after boosting on a fixed D12-0 booster

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